Peer Review Comments and Responses
Puerto Rico and the U.S. Virgin Islands

NOAA's National Weather Service
Office of Hydrologic Development
Hydrometeorological Design Studies Center
Silver Spring, Maryland

15 February 2006

Introduction

The Hydrometeorological Design Studies Center (HDSC) conducted a comprehensive peer review of the Puerto Rico and U.S. Virgin Island precipitation frequency project during the period November 3, 2005 to January 11, 2006. The review included the following draft items:

1. Point precipitation frequency estimates
2. Mean annual maximum 60-minute map
3. Mean annual maximum 24-hour map
4. 100-year 60-minute map
5. 100-year 24-hour map
6. Statistical Trend Analysis report
7. Temporal Analysis report

This document presents a consolidation of all the review comments collected during the 10-week review period and HDSC's response. We have used the original wording of the comments to make sure the meaning of the comment/question was not misconstrued and so that individual reviewers can identify their comments. HDSC requested comments from approximately 115 individuals and we received comments from 14 individuals. Some of the responses represented feedback from their staff. After parsing all of the comments, we found 47 unique comments which are included in this document.

Similar issues/comments were grouped together and are accompanied by a single response. The comments and their respective responses have been divided into seven categories:

1. **Comments on point precipitation frequency estimates**
2. **Spatial interpolation comments**
3. **Comments pertaining to statistical trend analysis report**
4. **Comments pertaining to temporal analysis report**
5. **General questions, comments and typographical errors**

1 Comments pertaining to point precipitation frequency estimates

1.1 *For daily stations (24-hour plus data only, e.g., Canovanas, Mayaguez AP, Humacao) you may not want to extend duration curves in precipitation-duration graphs below 24 hours where there is no data to support a line being drawn. Similarly (e.g., Cubuy, Botijas 1 Orocovis) do not extend the curves at the durations beyond 48 hr. where no data exists*.

It seems like this area would have small streams that are responsive to short duration rainfall events. The tables I looked at had as the shortest duration 24-hr durations, which seems long for this type of area. I expect that you were limited by data availability, but is there no way to use creative science to extrapolate to shorter durations? If you, who have the scientific tools and knowledge to do so, do not generate shorter duration values, those who need the values will have to try to guess at some values... likely with less success than a scientific approach.

Are there any other frequencies besides the 100 year and mean values [maps]*?*

Response: The preliminary information available for the peer review is a subset of the final information to be published resulting in gaps when displayed on the Precipitation Frequency Data Server. The final NOAA Atlas 14 Volume 3 results will provide frequencies of 1-year to 1000-year and durations of 5-minutes to 60-days for all locations in a point-and-click interface and as grids and maps.

The point estimates under review were directly computed from observed data available. Hourly stations had data for 5-minutes through 48-hours. Daily stations had data for 24-hour through 60-days. Stations with complete data (5-min through 60-day) had co-located gauges and we designate them as co-located hourly-daily stations. Once the spatial analysis is complete, all durations/frequencies will be available for all locations; there will be no gaps in the data (i.e. missing durations) at any point in the project area.

All of the input data into the spatial interpolation scheme is based on the duration bounds of the station data (i.e., daily, hourly, co-located daily and hourly). Any duration not represented by station data will be automatically interpolated. The spatial analysis will be described fully in the final documentation.

1.2 *I pulled off this type of preliminary information from the [Precipitation Frequency] Data Server for some 12 to 15 stations. Some of the precipitation depth vs annual exceedance probability plots look great whereas others indicate a large amount of durational convergence/divergence. I take it that these plotted relations will be smoothed in the final analysis?*

1.3 *Is there reason for or previous studies that showed similar flat slopes after 48-hours, for instance at Cerro Maravilla (66-2336)?*

Response: Yes, the plots you saw during the review represented the raw results from the L-moment software. The spatial interpolation scheme will smooth the raw results both temporally and spatially as to make them consistent with neighboring stations and other durations. Even so, some of the general patterns observed in the curves may remain after the smoothing. We considered these patterns carefully and found climatological justification for them. We included this climatological summary as part of the peer review at http://hdsc.nws.noaa.gov/hdsc/pfds/pr/pr_IDF_climatology_final.pdf.

1.4 *It seems reasonable to believe that Cacaos (for whatever reason) is an outlier and we tend to agree that it should be discarded. I really hate to discard a station with such data but we do not find a justification for this station collecting a significant amount of rainfall higher that its neighbor stations.*

Response: The observations and precipitation frequency estimates at this station were high, did not seem consistent with nearby stations, and was therefore on our suspect list. After receiving this comment and learning that the observer at the Cacaos station once had a tarp that drained toward the rain gauge, we deleted the station from the analysis.

1.5 *It is interesting and should be investigated, why we do not have a bulls eye maxima in the central northwest near the Maricao Fish hatchery station (66-5911). It always shows up in the climate data analysis and maps. It is a mountainous area. Can you check?*

Response: We investigated the Maricao Fish hatchery station, as well as the two nearby stations: Maricao (66-5906) and Maricao 2 SSW (66-5908). Although the means and precipitation frequency estimates at the Maricao Fish hatchery are slightly lower (hence preventing a maximum on the maps) , they are within acceptable limits as compared to the other two stations. Given the consistency in the observations and results at these three stations, we will not make changes to the regionalization or station data. However, we will be mindful of this region during the final spatial interpolation.

2 Comments pertaining to spatial interpolation and maps

2.1 *USVI – St. Thomas: Wintberg (elev. 600 ft) has 2-yr 24-hr value nearly 25% lower than Ft. Mylner (167 ft) (2.78" vs 3.65"). Without access to a high-resolution topographic map the rationale for such a difference escapes me. Wintberg also seems quite low compared with all stations on the other USVI, Culebra and Vieques, unless this is a very "shadowed" stations from the prevailing trades and with respect to hurricane winds which would likely have an easterly component as well in the heaviest rain scenarios*.

Response: The data at these stations supports the estimates. Nearly all of the annual maximums are higher at Estate Fort Mylner (67-2823) than Wintburg (67-9450) during their concurrent period of record from 1972 to 1995. The data at 67-9450 extends further through 2003 and is similar to its earlier record. The highest observed annual maximum for the period of record at 67-2823 was 15.00 inches on 4/18/1983 while 67-9450 observed 9.11 inches on 4/19/1983. However, the 2-day totals from this event were closer in magnitude with 17.50 inches at 67-2823 and 15.01 inches at 67-9450. With the relatively short period of record at these two stations differences such as observation time make a larger difference in the estimates than if the stations have longer periods of record. The records at these stations meet our criteria and do not require a change in our approach. In addition, maps of elevation reveal that 67-9450 is on the western side of an elevation barrier of almost 1,000 feet (305 m) while 67-2823 is on the east (upslope) side of this elevation barrier. This supports the existence of a rain shadow at 67-9450 with an easterly wind. Therefore, we are confident in the estimates at these two stations.

2.2 *Surprisingly large differences in pf values even at low elevations (Mayaguez Airport at 32 feet vs. Mayaguez City at 203 feet) where over 20% variation in 2-yr 24-hr. value (2.76" vs. 3.52"). Hacienda Constanza (elev. 925 feet), which might be presumed to have more topographic influence falls midway between these values at 3.05". It is unlikely that there are substantial moisture availability variations in these situations. However, there may be small-scale phenomena which account for these "discrepancies".*

Response: Mayaguez City (66-6073), with 104 years of data, has twice the period of record of Hacienda Constanza (66-4300) and Mayaguez Airport (66-6083). However, all stations meet our minimum requirement of at least 20 years of data to be included in the analysis. During the concurrent period of record many of the annual maximums were higher at 66-6073 than 66-6083 from the same event. For example, at 66-6073, 21.30 inches was measured on 9/22/1998 while just 12.00 inches was measured at 66-6083. Therefore, since 66-6073 and 66-6083 are clearly measuring different rainfall, we prefer not to make any changes to the regionalization or station data.

Even so, the spatial interpolation scheme appears to be accommodating this variation through the use of PRISM and smoothing algorithms. PRISM (and our unique use of it for precipitation frequency estimates) was specifically designed to incorporate climatological knowledge into its process. You'll notice that the contours generated by the spatial interpolation scheme are more in line with your expectations than the point data, keeping the highest values near Hacienda Constanza (66-4300) and the lowest near the Mayaguez Airport (66-6083). This scenario illustrates how using the regional L-moments method in conjunction with our spatial interpolation scheme produces reliable results that are consistent with the climatology.

2.3 *The map annual maximum 60-minute rainfall shows a broad maxima of 2.8" plus in the northwest quadrant of the island that is not reflected in the 60-minute exceedance map which even depicts a slight minimum (<4 inches) southwest of Dos Bocas (66-3431). Not sure if this is a result of the PRISM analysis, but appears slightly anomalous*.

Response: This was an observation we made as well. The smoothed spatial interpolation by PRISM at 66-3431 is actually the highest deviation from the observed data. We are going to review this area carefully in our final PRISM runs. However, we feel that the resulting patterns are likely reproducing the local climate regimes. The northwest quadrant of Puerto Rico is susceptible to frequent moderate rainfall events from thunderstorms hence the mean annual maximum is relatively high in this area. But rarely do these thunderstorms drop extremely heavy rainfall, which is reflected in the relatively low 100-year estimates.

2.4 *The 24-hour 100-year current analysis looks much like the general pattern indicated by the annual maximum 24-hr precipitation that was provided. However, this is not the case when comparing similar figures for the 60-minute duration especially for western PR. Is there a reason why the 24-hour looks so reasonably similar but there are significant differences at 60-minutes?*

Response: We carefully reviewed this issue and feel the 60-minute patterns are consistent with the climate regimes (see Response 2.3). During the initial internal evaluation of spatial results, it was clear that the spatially limited shorter duration dataset (hourly) was not sufficient to accurately resolve patterns at the final high spatial resolution (3-sec). Therefore, so-called hourly "pseudo data" were objectively generated at all daily-only stations to create a more coherent spatial pattern in the hourly durations over such complex terrain. The general 100-year 60-minute patterns did not change with the addition of the pseudo data, with one exception – in the middle of the island, estimates in/around 66-9432 (Toro Negro Forest) increased 18.2%. This increase occurs in an area that lacks hourly observing gages. The resulting spatial pattern is more consistent with climatological expectations and with Technical Paper 42. Additional information can be found in the 22nd Progress Report Section 3.6 Spatial Interpolation, Spatial Smoothing (http://www.nws.noaa.gov/ohd/hdsc/current-projects/PuertoRicoPR22.pdf). To further verify that the pseudo data were not changing the overall pattern, we compared the 60-minute mean annual maximum map that was generated without any pseudo data with the 2-year 60-minute map, which is statistically closest to the mean, and that was generated with pseudo data. We observed that the pseudo data did not change the overall pattern between the compared maps. We have concluded that the use of hourly pseudo data in the quantile maps adds climatologically sound definition to areas of complex terrain that are devoid of hourly observations.

2.5 *The exceedance probability curves do seem to reflect nicely some of the complex climatological patterns, such as the continued increases at longer durations in the El Yunque (Pico Del Este) area versus the central or western mountains (Adjuntas, Cerro Maravilla). I do question the fairly low short-duration values at El Yunque stations compared to the central mountain (2-yr. 60 min. value of 1.98" at Pico vs. 2.33" at Cerro, 2.44" at San Sebastain). Convective rainfall at such short-time scales would seem have more to do with storm-scale factors rather than mesoscale or terrain-induced phenomena. The paucity of hourly data leads to some questions at least about the physical mechanisms responsible for short duration (< 60-mins.) rainfall. In contrast to the longer duration events, elevation does not have a dominant role in short-duration rainfall as shown by the fact that San Sebastian (elev. 173) has higher 5 to 60 minute values than Cerro Marravilla (elev. 3684). It is perhaps beyond the purview of this report to address the causative factors here, but the isopluvial patterns drawn on the 60-minute maps may reflect the few stations available far more than actual variations in short-duration rainfall. The 19th Progress report discussed the reasons for the elimination of the USGS short-term data. That data may have still been useful in* *depicting the spatial distribution of short-duration rainfall in this complex terrain, which is so dependent on a few stations. Perhaps archived radar data from the San Juan WSR-88D would also be useful in depicting the rainfall distribution in this area, although I realize that is another entire project*.

Response: We agree short duration rainfall is influenced more by storm-scale factors rather than mesoscale or terrain-induced phenomena. In fact, the smooth interpolation of the mean annual 60-minute maximums is consistent with this theory. Although we are using a limited hourly dataset, it may be sufficient for resolving the smooth spatial patterns in the means because fewer stations are necessary to support such patterns. Additionally, the interpolation of the 60-minute means indirectly utilizes a much denser network of stations through the use of the PRISM-created mean annual precipitation, which is based on a larger dataset. As described in the response to 2.4, pseudo hourly data were developed at all daily-only stations to supplement the spatial density of the hourly quantiles for interpolation. Unfortunately, a radar study is beyond the scope and schedule of this project, but past investigations into radar use for our purposes has been inconclusive due to the relatively short periods of record and the absolute and spatial errors in radar fields, particularly in cases of extreme precipitation such as are not the subject of this project.

2.6 *For the 100-year 60-minute & 24-hour analysis for the island of St Croix, I note a rather large increase in the magnitude of precipitation in the NW portion of the island. Does one have station values to support this large increase? Your topo analysis provided does not give me the impression that the orographic enhanced precipitation should be that great*.

Response: There are several things influencing the high values on the NW portion of St Croix. (1) There are two stations (Annaly, 700', 27 years; Fountain, 250', 20 years) supporting the high values, (2) the elevation in this area reaches 1,000+ feet and does provide some orographic enhancement, (3) the PRISM-created mean annual precipitation map, from which the precipitation frequency maps are indirectly derived, indicates elevated values in this area. In fact, one may argue that the high values ought to extend slightly further east-northeast to pick up additional high terrain. Regardless, we will be mindful of this area during the final spatial interpolation.

2.7 [The area just northeast of] *station 66-4126 (Guayabal) to the southwest of Cacaos station has a maxima of 22 which also seems to be to high. There is a hill in that area but should not be that significant, could you also check on this one..*

Response: The lack of data in this area forces the estimates to be extrapolated up the terrain by the spatial interpolation scheme. The relationship between the mean annual maximum 24-hr precipitation and the mean annual precipitation suggests this area experiences relatively heavy precipitation. However, based on your concern, we will look at this area again during the final interpolation.

3 Comments pertaining to statistical trend analysis report

3.1 *The report does not mention the Atlantic Multidecadal Oscillation (AMO) and its relationship, if any, to rainfall in Puerto Rico and the USVI. Perhaps, describing such atmospheric phenomenon compared to the period of record of the gages utilized in this report may further explain the cause of the positive trend as shown in the report.*

Response: That is a good suggestion, but beyond the scope of this project. The purpose of the trend analysis is as a quality control measure to demonstrate that the annual maximum series data is independent, generally free of trends, and therefore appropriate for use in the precipitation frequency analysis.

3.2 *The title on figures should be posted at the bottom of the figure and not at the top. The maps included in figure A.3.1 and A.3.2 are very small and is difficult to identify the location of the stations*.

Response: Agreed, the titles have been moved below the figures. We will consider ways to make the maps clearer.

3.3 *In the second row of the introduction the appropriate word is stationary instead of the word constant. If the climate is stationary implies that the first and the second moments of the time series do not change with time, i.e., the autocorrelation function is independent of time*.

Response: Thank you we have changed it in the text.

3.4 *I'm not entirely certain what the value of the Statistical Trend Analysis is. It does not appear to definitively answer any question- the statistics are (as far as I can tell) profoundly inconclusive on the subject of trends. I suppose that I would encourage some discussion of what this is intended to convey. A small number of stations indicate some possibility of a positive trend over the period of record. I saw no discussion of whether or not that could have been attributable to measurement bias or systematic error (I would suspect that given no other evidence). I also saw no discussion of how the period of record might exert an impact on that. Unless I am mistaken, there were periods of distinct difference in the number of tropical cyclonic events over the twentieth century, particularly what appeared to be a lull during the latter half. How might things like that impact the statistics? Should they be considered as anomalies in a stable long-term process, as indicators that there is no overall stability in climate, or (as the press is likely to do) indicators of some anthropogenic impact on climate. I don't expect anyone to know the answer to these questions, but if you analyze for trends and publish the results of that analysis, shouldn't you at least discuss what lead you to do so? As it is, I saw the trend analysis as not contributing to the overall atlas in a meaningful way. I suppose that what I am saying is that the Introduction and/or conclusions sections should be fleshed out somewhat*.

Response: The current practice of precipitation (and river height and flow) frequency analysis makes the implicit assumption that past is prologue for the future. The purpose of our trend analysis is as a quality control measure to demonstrate that the annual maximum series data is independent, generally free of trends, and appropriate for use in the precipitation frequency analysis. Therefore, based on the results we were able to assume that the full period of the available historical record derived from rain gauges was suitable for use in this analysis even though there were some local instances of linear trends and shifts in mean in the data. This point is actually discussed in various other sections of the final documentation (which were not part of the review) and directs the user to refer to Appendix A.3 (the report reviewed here) for additional details. However, you make a good point and perhaps it would be good to include additional text covering this further in the Appendix as well.

Discussion or research into the causes of any observed trends is beyond the scope of this project.

3.5 *Regarding the time series trend analysis it would be useful to see a table showing the trend data at all the 55 available stations. This would not be too onerous a task if the station, percentage change and years of data were all that was listed. This would permit researchers to assess whether changes in station location, equipment, or observer were also partially responsible for trends and changes. Figures A.3.4 and A.3.5 were very interesting and it would be nice (albeit unlikely) to see more of these. The 30% increases at these stations seem very high since the most (42 of 55 showed) no trend at all and many if not most stations would have experienced the "outlier" hurricane events*.

Response: A list of the stations could certainly be provided upon request but will not be included in the final documentation to maintain consistency between the available documentation for all Volumes of NOAA Atlas 14. As you say, Figures A.3.4 and A.3.5 are provided as interesting examples of the types of trends/shifts observed in the data. Time and resources preclude us from creating any additional figures. The time series data will be available on the Precipitation Frequency Data Server and trend/shift statistics can be provided if one would like to conduct a more detailed review of additional stations in Puerto Rico.

3.6 *In the paragraph 2.1 Methods in row 7 the variable should be clearly defined. This variable is either the mean of the total rainfall observations or the mean of the only 1-day maximum precipitation time series*.

Response: The variable is the mean of the 1-day annual maximum series data. It has been clarified in the text.

3.7 *Section 2.2, first paragraph. Length of record is based on the 50 year criterion + additional criteria, right? Same section, last paragraph. This is a repetition of the first paragraph of this section*.

Response: Right. The stations used in the analysis were required to have at least 50 years of data and meet various criteria if there were any gaps in the record. There are similar wordings in the results descriptions, but they vary depending on the particular test.

3.8 *Section 2.1 Methods, second paragraph. (Start with Stations with gaps….) add "the following" before "additional criteria"*

Response: Thank you for the suggestion. The text has been added.

3.9 *Section 3.1 Methods. It is not clear what a "division of 1958" means*.

Response: The text was clarified to indicate that the year 1958 was used to divide the time periods that were tested for a shift. A division at 1958 was chosen because that was the end date for the previous estimates published in 1961. It allows us to test whether there are differences between the data used in the previous publication and the additional data we have used in this project.

3.10 *Page A.3-5, table A.3.3 and figure A.3.3. The table indicates there are eight stations that show a positive shift in the mean results yet on figure A.3.3 there are only seven such stations plotted. Am I missing part of the figure or has one station been left out on the figure*?

Response: Although all stations were plotted, the label for one was covered up by another label. We will correct the document.

3.11 *Page A.3-4, section 3.1, last sentence. It is stated " In this project, there were 20 stations that were screened out (not eligible) for the Mann Whitney test that were included for the t-test." Yet in section 3.2 (see bullets), you indicate that for both the t-test and the Mann Whitney test there are a total of 22 stations eligible. Where is this difference of 20 stations. Either the t-test should show 42 stations available and 22 for the Mann Whitney test OR there are 22 stations available for the t-test and only 2 stations available for the Mann Whitney test. Please clarify text*.

Response: You are correct, all stations eligible for the t-test were also eligible for the Mann Whitney test. The erroneous statement was actually a remnant of a previous trend analysis report written for NOAA Atlas 14 Volume 2. The text has been corrected.

3.12 *The south bias on the analysis looks different than I expected, but as you explained in the review materials it is probably because of single events such as 1985 and Georges. I would like to know if you have had that comment.*

Response: We presume you are referring to the geographical preference for upward trending stations in the south. The extent of our research and knowledge about this is contained in the report. And as we've said, unfortunately, we do not have time or resources to investigate causes of the trends further.

3.13 *In the paragraph 3.1 Shift in the mean results in row 7. There may be another justification of change in the mean of the process. The global warming may be a better justification to determine the shift in the mean. The limitation of having at least 30 observations on each side of the change* *it is not required all the times; it depends on the method of analysis. For instance the exponential weighted moving average method requires having at least 30 observations on the left side and 1 to 10 observations in the other side. Ramirez and Julca (2006) introduced an algorithm to detect local climate change. The algorithm is vary simple and is based on the fingerprint of an autoregressive process. Some applications are presented in this manuscript*.

Response: We appreciate your suggestion and will review the paper which you reference. However, given time and resource constraints it may be difficult to implement a change in the methods for this project. We will give it consideration and may be able to incorporate modifications in our future projects.

3.14 *In the paragraph 4. Specific Examples at row 11. Please replace 1996 by 1998, because hurricane Gorges occurred on September 22, 1998. This mistake was repeated on the next paragraph.*

The following document needs to accurately show the year of Hurricane Georges, which was 1998, not 1996. The error is in two instances. Statistical trend analysis of 1-day annual maximum series - via the review page or directly at http://hdsc.nws.noaa.gov/hdsc/pfds/pr/NA14Vol3_A3.pdf.

Response: Thank you for catching the typographical mistake. It has been corrected.

3.15 *Section 4. Specific examples. Second paragraph (Starts with "Figure A.3.5…" I don't understand how the data still exhibits a trend in the mean, but not a shift in the mean*.

Response: This station, Ponce 4 E (66-7292) does indeed exhibit a shift in mean. This will be made more clear in the text and figure caption.

3.16 *Page A.3-7, title of figure A.3.5. I do not understand that this plot indicates a decreasing linear trend. Looks to me like the trend is increasing - check the title of this figure*.

Response: Yes, that was a typographical error. It has been fixed to indicate an increasing linear trend.

3.17 *The legend on Figure A.3.4 (Failed to pass …) should be removed from the figure*.

Response: Agreed. It does not add information to the plot. It will be removed from Figure A.3.4 and A.3.5.

3.18 *Page A.3-6, section 4. It would be helpful if one would include a general descriptive location of the two stations provided as examples as part of the text*.

Response: Good suggestion. Text describing the general location has been added.

3.19 *The x's axis of Figure A.3.5. is shifted one unit. The year 2000 should coincide with the number 100. Apparently year 2000 is located in the number 101 in the x's axes*.

Response: This is the result of the convention used during the plotting. The first year of record is plotted as year 1, not year 0. Therefore, given a record starting in 1900, the year 2000 would be located at year 101.

3.20 *Figure A.3.5. does not reveal the effects of hurricane Hortense. This hurricane made a landfall in the south part of Puerto Rico in September 9, 1996 and caused flooding in Ponce, PR. Figure A.3.5 shows approximately 3.5 inches, which looks very small. I would recommend checking this particular value*.

Response: We reviewed this particular value and could not find error in it. Our data for this event is verified through the original surface observation form for September 1996 at Ponce 4E (66-

7292) obtained through NOAA's password-protected "Web Search Store Retrieve Display" (WSSRD) (http://noaa.imcwv.com/) which shows a total of 5.22" fell during Hurricane Hortense (3.46" + 1.76"). This also agrees with the National Hurricane Center's preliminary report for Hurricane Hortense (http://www.nhc.noaa.gov/1996hortense.html). Without additional information, we are inclined to believe the station observations. The flooding you mentioned was perhaps a direct result of higher precipitation amounts (more than 16 inches) that fell in the mountains to the north during the event (see Figure 3.3.1 from the National Hurricane Center's report).

Figure 3.3.1. National Hurricane Center's map of rainfall totals for Puerto Rico during Hurricane Hortense.

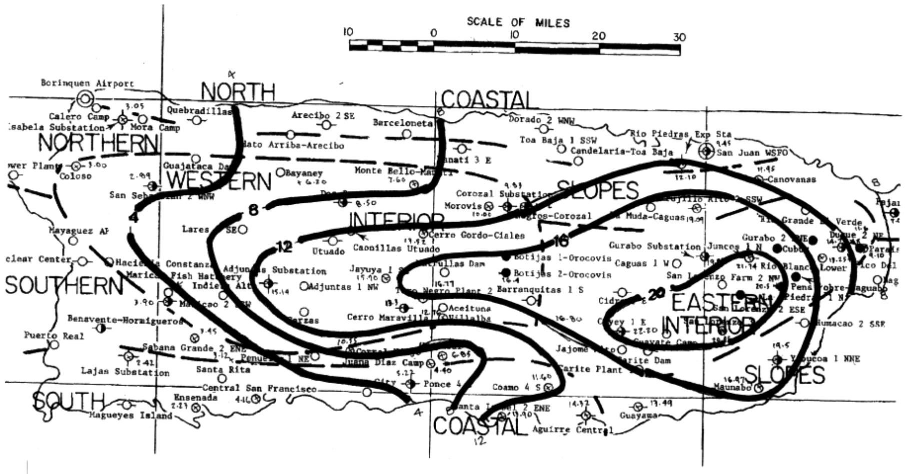
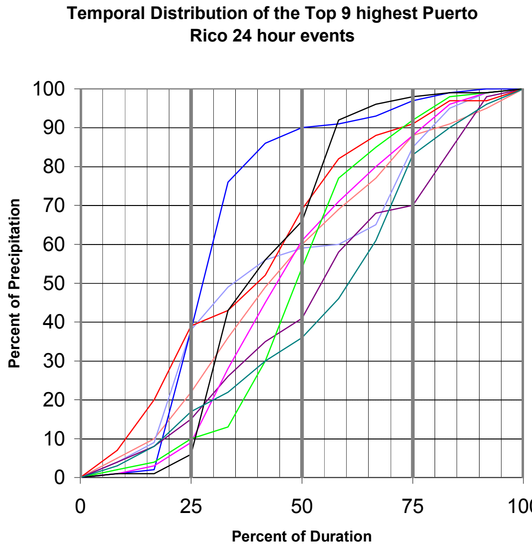


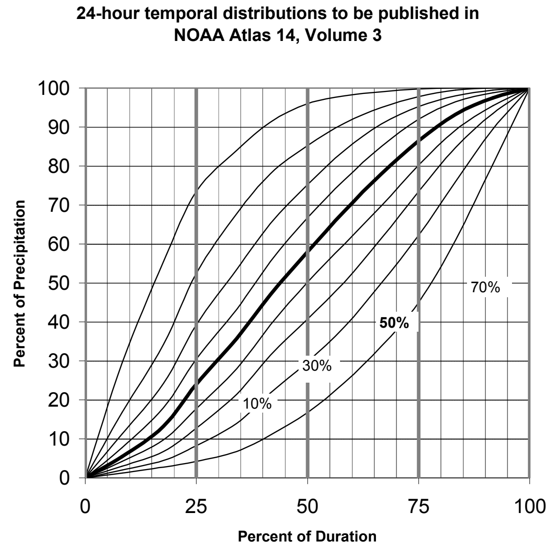
Fig. 5 Hurricane rainfall totals (inches) over Puerto Rico during 9-10 September 1996.

4 Comments pertaining to temporal analysis report

4.1 Regarding the temporal distributions of heavy precipitation, the methodology is sound but it would be of interest to see at least some data from more extreme events rather than just the 2-year ARI. Perhaps using a 10-yr ARI if that sample was stable and for just a single duration. The interpretation section (3) is useful but it might be useful to provide a "real-world" example of a storm distribution. Using a single extreme event would demonstrate how an actual storm distribution might vary (or conform nicely) with the theoretical graphs presented.

Response: The temporal distributions are based on the summary of all types of precipitation events and meant to be used with the precipitation frequency estimates. The temporal distributions were created based on events greater than the 2-year ARI, which includes events up to and even greater than the 100-year ARI. Comparison between distributions based on the 2-year ARI and greater versus 25-year ARI and greater showed no noteworthy difference except that the reduced number of samples resulted in less smooth curves. The "real world" examples are variable and mostly fall between the 10 and 90 percent curves. For instance, the nine highest 24-hour events from all hourly stations in the project area are shown in the figure below on the left. The event totals in these nine cases ranged from 22.20 to 17.00 inches. Notice the variability and lack of smoothness; yet the curves are generally within the 10 and 90 percent curves shown on the right which are the distributions to be published in NOAA Atlas 14, Volume 3. Because of the lack of stability and smoothness, we do not plan to publish this example.





4.2 *The temporal distribution information appears quite consistent with what I've seen in earlier volumes of Atlas 14 and in other recent research. The Huff-type curves are very useful if you understand what they represent. The use of such curves gives a common ground for comparison among such work worldwide. There appears to be adequate documentation and information for any purpose I can conceive at this time. The percentile ranking allows for the consideration of uncertainty in this arena, also.*

Response: Thank you for the comment.

4.3 *Section 2, Methodology, first paragraph. Add "storm" before duration, so it will read: "storms in order to be consistent with the way storm duration was defined…"*

Response: There is a difference between "storm" duration and the specific case durations used in this study. The cases have a specific definition here. The starting time of the duration accumulation was defined in the same way as it was for the precipitation frequency estimates. The start and end times were set to capture the highest accumulation for a duration by a moving time window technique. As a result, the accumulation cases may contain parts of one, or more than one, precipitation event.

4.4 *Page A.1.1, section 2, 4th paragraph, first sentence. It is stated that some regional analysis was made of the station precipitation on a temporal basis and no significant variation was indicated. I would like to be made aware of the sub-regional breakdown that was used for the analysis. Did you break regions by coastal/nonorographic vs interior/orographic or what exactly was done for this analysis. A brief explanation in the text or figure would be helpful.*

Response: The regions used were the same hourly regions used for the precipitation frequency analysis. We will make this clear in the final documentation.

5 General questions, comments and typographical errors

5.1 *The easterly winds during winter time play an important role bringing humidity into the island and stimulate orographical rainfall in the mountain region of Puerto Rico. Cold fronts cover large areas of cloud and precipitation during winter times.*

The easterly waves occur during the rainy season (May to October) and generate large amounts of rainfall in the Caribbean basin. The easterly waves generate low pressure systems in the east part of Puerto Rico creating several days of rainfall, usually 2 to 3 days, due to instability and thermal convection.

Reference: Ramirez-Beltran, N.D., and Jualca, O. Detection of Local Climate Change. 18th Conference on Climate Variability and Change, 86th Annual AMS Meeting. Georgia Atlanta, *January 29-February 2, 2006*

Response: Thank you for these valuable comments and the reference.

5.2 *Would like to see some discussion about differences in final values between NOAA Atlas14 and the soon-to-be displaced Technical Paper 42 for PR/USVI. The time series trend analysis did discuss the change in mean trends between pre- and post 1958 but I didn't see where or how this might have impacted changes in the precipitation frequency values [between NOAA Atlas 14 and Technical Paper 42].*

Response: In the final documentation, we will include a brief discussion of the differences in the estimates of NOAA Atlas 14 and Technical Paper 42 as well as a map showing the differences between the 100-year 24-hour estimates. It will be found in Section 7, Interpretation.

5.3 *I can't conclude without a jab at pure web-based publishing. I am an old-fashioned person who believes in things I can touch. I am not certain from what I've seen so far whether or not there will be a hard-copy "master document" somewhere, but I hope so. In the end, electronic media are volatile. Over my engineering career, I've seen many examples of electronic record "perpetuation" that ultimately failed due to money or manpower constraints that could not be foreseen at the time of origin. I am skeptical- but I realize I am in the minority and a dinosaur. This is great work, and I'd hate to see it lost in some cataclysmic virtual equivalent to the burning of the Great Library at Alexandria.*

Response: We recognize your concern, but in accordance with the E-Government Act of 2002, NOAA Atlas 14 is an on-line document. The documentation and the maps will be made available in PDF format so that a user can print them if they wish. Some of the other electronic artifacts are also printable. A limited budget is also a contributing factor to any hard-copy versions of the atlas and electronic publication allows us to publish several orders of magnitude more information than we would be able to in hard copy.

5.4 *For the majority of issues, it is obvious that the group performing this work has become very comfortable and capable with the Hosking and Wallis methodology and with the tasks involved in doing extensive analyses like this. Considering the magnitude of effort that must go into this, I must say that I consider this work to be fantastic. I did not try every station or possible interpolation- not being familiar with the area I probably would not have recognized a major blunder anyway.*

Response: We appreciate your comments and thank you for taking a look.

5.5 *I have no personal frame of reference whatsoever regarding the magnitude and reasonability of the actual numbers that come from the Precipitation Frequency Data Server- I must assume that they are reasonable. The web services appear to work reliably and give consistent information in several forms. I am happy to see that the date and time of retrieval are documented on the reports- I think that is an essential detail. Spatial interpolation also appears to work consistently and reliably. I really appreciate the confidence intervals and other representations of uncertainty- that information was sorely lacking in previous work. Its presence gives the ability to enhance the credibility of work based on this information tremendously.*

Response: Thank you for your comments, and we agree, the confidence intervals add a tremendous amount of value and information to NOAA Atlas 14.

5.6 *It would be good if the map showing the rainfall stations also included the watershed boundaries so it could be easily seen which stations corresponded to which watersheds.*

Response: We will consider this as an enhancement in the future. With the final release, we will provide GIS compatible grids of the estimates so a user can easily download the data and overlay such boundaries.

5.7 *I noticed also that your precip duration/frequency tables were in the intensity units of in/hr, which I agree is intensity values. It seems like many or most users though are more likely to have precip accumulation amounts for various durations (e.g. 6-hr, 24-hr, storm total, etc). Thus it might be nice to at least offer tables in accumulated formats as an optional product that the user can select. Perhaps it was there and I missed it in my less than thorough review.*

Response: The PFDS does in fact offer two types of output -- intensity (in/hr or mm/hr) or depth (in or mm).

5.8 *I welcome that the methodoloogy is no longer tied to the Gumbel Distribution but has moved to far more appropriate, particularly the GEV, and Peaks over Thereshold.*

Response: Thank you for the comment. We agree that the current state of the science (i.e., a regional approach using L-moments) is a welcome advancement over previous techniques. We actually found in Puerto Rico that, although GEV and other distributions were tested, the generalized normal (GNO) distribution was most appropriate to fit the data. Details will be forthcoming in our final documentation.

5.9 *Regarding L-Moments estimation, I prefer to perform the analyses within and between models, through a Bayesian Approach. There is a tendency to under-estimate high floods, doing the estimation via "plug-in" estimates, and that may be serious specially for very large values, far in the tail.*

Response: Thank you for your comment and your mention of using the Bayesian approach for frequency analysis. This provides an opportunity to briefly discuss the approach that HDSC is using for the updates by understanding the difference between the two approaches.

First of all, it could be useful for us if you would provide details or examples of your analyses, particularly where high floods might be under-estimated through "plug-in" estimates. However, regional L-moments, as we have used here, have shown advantages in modeling extremes, especially for very large events far in the tail producing more robust and reliable quantile estimates. Below is a brief comparison of the classic frequency analysis and the Bayesian analysis approaches with respect to modeling hydrologic extremes.

Currently in statistics, there are two major approaches: Frequency or Classic Approach and Bayesian Approach. In frequency analysis of hydrometeorological extremes, the Frequency Approach considers a sample series x_i ($i = 1, 2, \ldots, n$) as a realization randomly drawn from an unknown population X that is characterized by a distribution with a set of fixed parameters describing the properties of the population. The distribution and its parameters uniquely determine the population and can be estimated based on the sample data. There is no way to obtain the population distribution or parameters through a theoretical analysis. Due to sampling error and non-linearity, the parameter estimates are unstable based on single-station analyses or Conventional Moments Method. In NOAA Atlas 14, HDSC has demonstrated advantages, using real data, of the regional analysis using the L-moments Method to provide stable quantile estimates in terms of robustness and reliability. The method is described in detail in "Regional frequency analysis, an approach using L-moments" by Hosking and Wallis (1997).

The Bayesian Approach also considers a parametric distribution to model the sample data. However, unlike the Frequency Approach, the Bayesian Approach views the parameters of the distribution as random variables that can be estimated through the use of some initial, or prior, information. Then, the prior information is combined with the sample data together to transform into a posterior distribution. The key of the transformation is the adjustment of the prior probability to the posterior probability. The quantiles then are estimated based only on the posterior probability. The Bayesian approach is based on the Bayes's theorem, which can be developed from the concept of conditional probability as written below:

$$P\{B/A\} = \frac{P\{A/B\}P\{B\}}{P\{A\}} = P\{B\} * \frac{P\{A/B\}}{P\{A\}} = \frac{P\{A/B\}P\{B\}}{P\{A/B\}P\{B\} + P(A/\overline{B}\}P\{\overline{B}\}} = \frac{1}{1 + \frac{P\{A/\overline{B}\}P\{\overline{B}\}}{P\{A/B\}P\{B\}}}$$

where P{B} is called a prior probability and P{B/A} is called posterior probability, as A is known to have happened and the relevant probability for B is now the conditional probability of B given A. Here, $\overline{B}$ is the opposite event of B. Bayes's theorem can be thought of a mechanism for updating a prior probability to a posterior probability when the additional information that event A has occurred becomes available. From the equation above, it is clear that the updating is accomplished through multiplication of the prior probability P{B} by P{A/B}/P{A}. Here, P{A/B} and/or $P\{A/\overline{B}\}$ is called the likelihood function of B.

So far, the Bayesian Approach in appearance seems better because it uses more information (observations plus the initial information about the parameters) than the Frequency Approach (observations only). But, the major reservation regarding the application of the Bayesian Approach to frequency analysis is the selection of prior information, such as elevation and mean precipitation over a certain period of time. The determination of a prior probability is very difficult in the real world of modeling extremes and sometimes it becomes a subjective process.

Generally speaking, we have reservations about the application of the Bayesian Approach to frequency analysis of hydrologic extremes at least for now when data are too limited in the determination of valuable prior events, although it is seeing wider application in other fields.

5.10 *Please provide information on the inter-event dry period used for the analyses.*

Response: The estimates are based on the analysis of annual maximum series and then converted to partial duration series results. An annual maximum series is constructed by taking the highest accumulated precipitation for a particular duration in each successive year of record. As such the maximums are inherently independent of one another and no inter-event dry period is necessary. A partial duration series is constructed by taking all of the highest cases above a threshold regardless of the year in which the case occurred. In this Atlas, partial duration series consist of the N largest cases in the period of record, where N is the number of years in the period of record at the particular observing station. Independence of the partial duration maximums was assured by selecting events separated by at least one dry day. The final documentation will provide the details of the maximum extraction procedure.

5.11 *The topo-map elevations are incorrect. The highest point in Puerto Rico is Cerro del Punta at 4,389 ft. (1,338m), not 3693m (13,000ft) as indicated in the legend.*

Response: Thank you, we will resolve this oversight.

5.12 *I reviewed the subject information and was familiarized with the dataset subject to frequency and trend analysis. The maps and tables shown coincide with work produced by the Office of Water Plan of Puerto Rico, with the exception of the use of 128 National Oceanographic and Atmospheric (NOAA) rainfall stations. The Office of the Water Plan evaluated frequency and trends for 134 stations. Obviously the methodology used for screening of stations was also different. In your analysis a shift in the estimate of the mean was used while for the purpose of our evaluation we used the duration or extend for the available information or period of data. I used those stations in which the data period extends for more than 20 years. However, both analyses are very similar when comparing the results in magnitude and frequency.*

Of importance was the correction of 30-year statistics of the old technical paper 42 which are currently showing recurrence intervals of about 10-years. I also suggest the evaluation of extreme events rainfall, more specifically the pass of a high-convection low pressure system over the *island of Puerto Rico at a speed of less than 5 miles per hour. Typically, hurricanes that hit the island have a horizontal movement of 8 to 15 miles per hour reducing the amount of rainfall over the land mass. Hurricane Mitch produced substantial amounts of rainfall over Honduras when it became stationary during days beginning October 28, 1998.*

Response: Thank you for your comment and information. It is good to know that there is consistency between your analysis and ours. In our final documentation we will provide a brief comparison of our estimates with those from Technical Paper 42. We should note that our estimates are based on an analysis of all observations in the period of record and so incorporate all observed extremes within the limitations of the distribution and reliability of rainfall gages and the construction of annual maximum and partial duration series. We have not screened out or given unequal weight to any particular events. We assume that the period of record we use represents the range of variability in the underlying population fairly. By doing this we ensure that our results represent the variability of the extreme rainfall climatology that must be accounted for in engineering design.